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In generic range-dependent environments the acoustic ray equations define a nonintegrable Hamiltonian system. Solutions to such systems of equations are known to exhibit chaotic behavior, i.e., extreme sensitivity and exponential divergence of nearby rays. The objective of this work was to determine whether the chaotic motion of ray trajectories imposes any limitation on the ability to predict finite frequency acoustic wavefields. This imposes a limitation of one's ability to predict (compute) ray trajectories.

Acoustic ray chaos in the ocean environment was studied analytically and numerically. Both idealized and realistic ocean models were studied. The influence of both boundary and volume structure was considered. The purpose of these studies was to quantify - in terms of a "predictability horizon" - our understanding of ray chaos in the ocean environment.

Wave chaos was investigated numerically in an environment in which the corresponding chaotic behavior is understood and quantifiable. Predictability was studied by forward and backward propagating PE wavefields in an attempt to determine whether finite frequency wavefields lose memory of their initial conditions (as in the case for the corresponding ray trajectories).

The results of our numerical and analytical studies are that: 1) ray predictability horizons are typically several thousand km for mesoscale (volume) structures, several hundred km for internal wave structures, or, where range-dependent boundary interactions are involved, the distance corresponding to ten or fewer such interactions; and 2) no evidence of any limitation on predictability associated with chaotic behavior was found in PE wavefields computed using the split-step Fourier algorithm.

The publications listed below acknowledge support from this contract.

Palmer, D.R., M.G. Brown, F.D. Tappert, and H.F. Bezdek (1988) "Classical chaos in nonseparable wave propagation problems," *Geophys. Res. Lett.* 15, 569-572.

Brown, M.G., F.D. Tappert, G.J. Goni, and K.B. Smith (1991) "Chaos in underwater acoustics," in Ocean Variability and Acoustic Propagation, J. Potter and A. Warn-Varnas (eds), Kluwer Academic Publishers, 139-160.

Brown, M.G., F.D. Tappert and S.E.R.B. Sundaram (1991) "Chaos in small amplitude surface gravity waves over slowly varying bathymetry," *J. Fluid Mech.* 227, 35-46.

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Tappert, F.D., M.G. Brown, and G.J. Goni (1991) "Weak chaos in area-preserving mapping for sound ray propagation," *Phys. Lett. A* 153, 181-185.

Goni, G.J. (1991) "Ray and wave chaos in underwater acoustics," Ph.D. dissertation, University of Miami.

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